Proceeding: INQUIRY CONCERNING THE DEPLOYMENT OF ADVANCED TELECOMMUNI
CAPABILITY TO ALL AMERICANS IN A REASONABLE AND TIMELY FASHI
Applicant Name: Progress and Freedom Foundation
Proceeding Name: 98-146 Author Name: Charles A. Eldering [redacted]
Lawfirm Name: Telecom Partners Ltd.
Contact Name: applicant_name Contact Email: celdering@tpltd.com
Address Line 1: 1301 K Street N.W
Address Line 2: Suite 550 E.
City: Washington State: DC
Zip Code: 20005 Postal Code:
Submission Type: CO Submission Status: ACCEPTED Viewing Status: UNRESTRICTED
Subject:
DA Number: Exparte Late Filed: File Number:
Calendar Date Filed: 09/15/1998 4:59:26 P Date Disseminated: 09/18/1998 Filed From: INTERNET
Official Date Filed: 09/15/1998 Date Released/Denied: Initials:
Confirmation #1998915603960 Date Filed:

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996	)	CC Docket 98-146

COMMENTS OF THE PROGRESS AND FREEDOM FOUNDATION

Jeffrey A. Eisenach
President
PROGRESS & FREEDOM FOUNDATION
1301 K Street N.W.
Suite 550 E.
Washington, D.C. 20005
(202) 289-8928
(202) 289-6079 Facsimile

Charles A. Eldering
Adjunct Fellow
PROGRESS AND FREEDOM FOUNDATION
and
President
Telecom Partners Ltd.
900 Town Center
New Britain, PA 18901

September 14, 1998

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996	)	CC Docket 98-146

COMMENTS OF THE PROGRESS AND FREEDOM FOUNDATION

Table of Contents

I. INTRODUCTION AND SUMMARY 1
A. Intermodal competition vs. regulation 2
B. The slippery slope of regulating advanced services 3
C. Containment of regulation: differentiating historically regulated services from advanced telecommunications services 5
II. DEFINING "BROADBAND," "ADVANCED TELECOMMUNICATIONS SERVICES," AND "REASONABLE AND TIMELY FASHION" 7
A. "Broadband" and "advanced telecommunications capability" 7
B. Overview of technologies for "advanced telecommunications capability" 7
C. "Reasonable and timely fashion" 10
III. THE DEMAND FOR ADVANCED TELECOMMUNICATIONS SERVICES 11
A. Broadband Demand in Residential Markets 14
B. Broadband Demand in Business Markets 17
C. Supply and Demand 20
IV. TECHNOLOGIES FOR PROVIDING ADVANCED TELECOMMUNICATIONS SERVICES 23
A. Cable television based ("cable modem") technologies 25

B. Upgrading telephony networks via digital subscriber loop ("xDSL") technologies 28
C. Other broadband technologies 34
V. REMOVING BARRIERS TO COMPETITION AND DEPLOYING ADVANCED TELECOMMUNICATIONS CAPABILITIES ON A "REASONABLE AND TIMELY BASIS" 39
A. The history of cable regulation gives a clear indication as to the effect of regulation on growth 40
B. Deployment of broadband capable networks requires substantial investment which will only occur in a deregulated environment 42
C. Removing barriers to broadband investment can be accomplished through a containment policy for regulation 52
D. Universal service issues 54
VI. CONCLUSIONS 55
A. Intermodal competition, not regulation, is the key to encouraging the deployment of advanced telecommunications capability 55
B. Harmonization of public policy towards advanced telecommunications capability networks can only be accomplished through deregulation 56
C. Anti-trust vigilance, not prophylactic regulation, is the key to encouraging deployment of advanced telecommunications capability 58
APPENDIX A: A PROPOSAL FOR PACKET BASED DEFINITION OF BROADBAND SERVICES AND CONTAINMENT OF REGULATION 60
Overview of Packet Technology 62
Why Packet Technology is Different From Circuit Switched Technology 64
Deregulating Packet-Switched Technologies 67
Defining Packet Based Services 68
Interconnection and Unbundling in a Broadband Environment 73
Cost Allocation 75
Conclusions 77
APPENDIX B: DIGITAL BROADBAND WORKING GROUP BRIEFING ATTENDEES 79

I. INTRODUCTION AND SUMMARY

The Progress & Freedom Foundation ("PFF") is a private, non-profit, non-partisan idea center which was established in 1993 and studies the impact of the digital revolution and its implications for public policy. PFF makes these comments in an effort to educate the Commission and the general public as to what public policies will best encourage the deployment of broadband services, enable continued expansion of the Internet, and foster the growth of electronic commerce. Much of what is presented in these comments has been formed from contributions from a number of industry leaders in the telecommunications, networking and computer industries, based on meetings held in the last 18 months as part of its "Digital Broadband Working Group.[1]"

Through this activity and its other research, PFF has accumulated a substantial body of information, expertise and analysis relating to the issues addressed in this proceeding. This research suggests that competition, not regulation, is the appropriate model for the market for broadband digital communications services. While continued regulation of certain traditional services (i.e. Plain Old Telephony Service, "POTS") arguably is necessary, at least during a transitional period, the threat of regulatory spillover from the traditional telecommunications world into the digital broadband world represents a clear and present danger to investment in and deployment of digital broadband services. This analysis leads, in turn, to the suggestion that the Federal government adopt a "containment philosophy" for regulation, in which the narrowband infrastructure is deregulated according to the Telecommunications Act of 1996 ("the Act") and entrants are provided

---

[1] The Digital Broadband Working Group was convened by The Progress & Freedom Foundation at the request of Hewlett-Packard Chairman, President and Chief Executive Officer Lewis E. Platt and US West President and Chief Executive Officer Solomon J. Trujillo. Participants in the group's several meetings included representatives of all major segments of the computing and communications industries, and are listed in Appendix B of this filing. The Progress & Freedom Foundation is grateful to all of those who participated. The views presented here, however, are those of the authors and do not necessarily reflect the views of the Digital Broadband Working Group as a whole or of any of its individual participants.

access to the basic network elements including unbundled loops, but in which digital broadband services are left wholly unregulated.

PFF offers herein its comments on CC Docket 98-146, the Notice of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996 (hereafter referred to as the "NOI"). In the separate Memorandum Opinion/Order and Notice of Proposed Rulemaking, Petition of Bell Atlantic Corporation for Relief From Barriers to Deployment of Advanced Telecommunications Services et. Al. (CC Docket Nos. 98-11 et al., hereafter referred to as the "NRPM") the Commission proposes the establishment of separate affiliates by incumbent Local Exchange Carriers ("LECs") as a means of providing advanced telecommunications capabilities on a "deregulated" basis. PFF is not making separate comments on the Opinion/Order but makes references to the Opinion/Order and the concept of a separate subsidiary for data in the context of the Notice of Inquiry.

A. Intermodal competition vs. regulation

The information gathered in PFF's studies clearly indicates that intermodal competition – the competition which can occur between the wired local loop network operators (cable TV providers, incumbent Local Exchange Carriers, and competitive Local Exchange Carriers) and between the wired local loop network operators and their wireless counterparts (fixed wireless, mobile, and satellite) – has the potential to provide a rich and varied array of advanced telecommunications services to Americans at significant penetration rates. However, intermodal competition will be stifled by attempts to "level the playing field," which have the effect of raising entry barriers for network operators desiring to provide advanced services. By reducing the incentive to invest on the part of many participants, such efforts delay deployment of the

infrastructure required to support advanced services at high penetration rates. The ability to serve all Americans, particularly those in rural areas, depends on the ability of network operators to obtain the appropriate economies of scale and scope in their deployments. Regulation of those deployments is likely to reduce their chances of obtaining either of these economic factors and could severely retard the deployment of advanced infrastructures.

PFF's analysis of the technologies available for advanced telecommunications services indicates that there are subtle differences between competing technologies that will result in different service types, features and pricing, based on the architecture and business model each network operator/service provider adopts. The beauty of the Internet and the tremendous growth in electronic commerce that it is fostering is that it provides a common thread under which all of these architectures and services can operate. The previous models for regulation, based on telephone services and technology, broadcast services, or cable television, are simply inadequate, do not reflect the nature of advanced telecommunications capabilities and the Internet, and cannot possibly keep pace with the growth of the Internet and electronic commerce. Only by allowing competition to flourish can the Commission assure that advanced telecommunications services are deployed in a "reasonable and timely fashion" as required by Section 706 of the Act.

B. The slippery slope of regulating advanced services

The Commission is tasked with implementing the Act and accordingly must ensure that all of the Act's requirements with respect to unbundling, resale, interconnection and ILEC entry into long distance are met. Similarly, the Commission must, as specified in Section 706 of the Act,[2] determine how best to encourage the deployment "on a reasonable and timely basis of advanced

---

[2] Pub. L. 104-104, Title VII, § 706, Feb. 8, 1996, 110 Stat. 153, reproduced in the notes under 47 U.S.C § 157.

telecommunications capabilities to all Americans...." Although the Act specifies that one of the mechanisms for encouraging the deployment of advanced telecommunications capability to all Americans is regulatory forbearance, the Commission has determined in the NPRM[3] that it does not have the statutory authority to forbear from Sections 251(c) and/or 271. This conclusion rests, in turn, on the Commission's conclusion that "advanced services offered by incumbent LECs are either 'telephone exchange service' or 'exchange service.'"[4] This definition, which the Commission justifies based on a singular reference to the Federal-State Joint Board on Universal Service, threatens to drag all advanced telecommunications services into a complex system of regulation which is in no way prepared to deal with the Internet, electronic commerce, and the emerging dependence of the economy on the transport of digital information.

Having made such a definition, the Commission would seem to have no choice but to examine each and every advanced telecommunication service to determine how best to regulate that offering. Even if incumbent LECs adopt the option of creating separate subsidiaries, the role of the Commission in the regulation of advanced telecommunication services is bound to increase rather than decrease. Many will now ask, for example, why Title VI cable operators are not required to establish separate subsidiaries for their data services, or be forced to comply with interconnection, unbundling and resale requirements. Others will insist – and, indeed, the NPRM implies – that the rules for separate subsidiaries should eliminate *any* competitive advantages incumbent LECs have in the offering of advanced telecommunications services (including advantages associated with economic efficiencies). Such an approach raises the obvious question of why firms would enter markets in which they are prohibited from having a competitive advantage. It also ensures

---

[3] NPRM, paras. 18, 69-79.

[4] NPRM, paras. 40-42.

extensive, intrusive, and complex regulation (accompanied by lengthy regulatory delays and litigation) with respect to how separate subsidiaries are established and operated. Rather than limiting the Commission's role ensuring that competitive LECs have adequate access to unbundled twisted wire pairs and the ability to collocate in a cost-effective manner, the NPRM puts the Commission on the road to regulating the deployment and marketing of all advanced telecommunications capabilities.

C. Containment of regulation: differentiating historically regulated services from advanced telecommunications services

The alternative is to separate historically regulated services from advanced services. Specifically, as PFF's research demonstrates, the Commission could establish a "containment policy" for regulation in which packet based services are distinguished from circuit switched services, with intrusive regulation limited to circuit switched services.

This delineation raises issues with respect to the erosion of universal service subsidization by a migration of services to unregulated packet based systems, and also could require in frequency unbundling of twisted wire pairs. While this approach has, like any other public policy, implementation details which must be addressed, it is certainly preferable to "harmonization through regulation" in which each and every aspect of advanced telecommunications services are regulated.

In summary, the PFF research indicates that a "containment philosophy" with respect to telecommunications regulation can be developed in which packet based services are left entirely unregulated. For local loop applications, a data rate requirement of 1.5 Mb/s in the network-subscriber direction and 384 kb/s in the subscriber-network direction would be applied to ensure

that the telecommunications capability can support advanced services. The specifics of this proposal are discussed further in Appendix A.

PFF recognizes that such a proposal reflects only one means in which the Commission can promote the timely deployment of advanced telecommunications capability to all Americans, and urges the Commission to explore in depth any and all steps to prevent the unnecessary regulation of advanced services.

II. DEFINING "BROADBAND," "ADVANCED TELECOMMUNICATIONS SERVICES," AND "REASONABLE AND TIMELY FASHION"

A. "Broadband" and "advanced telecommunications capability"

In the NOI the Commission asks commentators to define what is meant by "advanced telecommunications services"[5] and "broadband."[6] As discussed at greater length in Appendix A, sound public policy for the deregulation of advanced services can be based on a definitions for these terms which encompass all emerging packet based services and which excludes all presently regulated circuit switched and presently regulated packet services (e.g. Frame Relay). Furthermore, consistent with the clear intent of Congress, as expressed in Sec. 706 and elsewhere in the Act, any such definition should be as expansive as practicable, permitting the Internet to continue to grow in a marketplace environment, not a regulated one.

B. Overview of technologies for "advanced telecommunications capability"

As will be discussed in Section IV, there are a number of technologies capable of providing advanced telecommunications services. Each of these technologies has subtleties associated with the architecture which prevents a precise "apples to apples" comparison, but such differences are precisely why intermodal competition provides an alternative to regulation. If growth can occur free of regulatory barriers, consumers will have the ability to choose from a variety of services offered via a number of delivery mechanisms.

---

[5] NOI, para. 13.

[6] NOI, para. 14.

The telephone industry technology which is envisioned as being "broadband capable" is the family of digital subscriber loop technologies, referred to in general as "xDSL."[7] The advantage of the xDSL technologies is that they utilize a significant portion of the existing copper telephone wires which already connect each home and business to the telephone network to provide broadband services. The ability to utilize the existing infrastructure means that advanced telecommunications services could be deployed without creating an entirely new plant. However, many existing twisted wire pair connections require conditioning in order to provide xDSL services, and if penetration rates and data rates to and from the homes are to become significant, fiber optic access systems (field based terminals connected to the central office or point of presence via a fiber optic cable) will need to be deployed in order to support xDSL networks.

Cable networks, which are broadband by definition, can support advanced telecommunications services via "cable modem" technology. Cable modems allow subscribers to use the existing cable system to receive data which is sent on downstream frequencies, and to transmit data from an individual subscriber on an upstream frequency. The advantage of cable modem technology is that it can be deployed on existing cable TV infrastructures. However, this is also the weakness of cable modem technology, cable TV's architecture requires that bandwidth be shared amongst all of the subscribers on the node, leading to bandwidth limitations in the downstream, and "noise funneling" problems in the upstream which can make two-way cable systems unreliable.[8]

---

[7] xDSL includes High Speed Digital Subscriber Line (HDSL) technologies for providing up to 2 Mb/s of bi-directional data service over two twisted wire pairs, Asymmetric Digital Subscriber Line (ADSL) technology which can provide data rates of up to 6 Mb/s in the downstream and 640 kb/s in the upstream direction, and Very High Speed Digital Subscriber Line (VDSL) technology, which can support data rates of up to 25 Mb/s in the downstream over a limited distance.

[8] C. Eldering, N. Himayat and F.M. Gardner, "CATV return path characterization for reliable communications," *IEEE Communications Magazine*, vol. 33, no. 8, pp. 62-69 (August 1995).

Comparing telephone and cable based technologies from an economic perspective indicates that while cable systems are inherently less costly than telephone systems, upgrading the broadcast based cable architecture for two-way services can result in per-subscriber costs which are higher than the costs for a "switched" telephone type architecture in which each subscriber has access to a specific drop cable.[9] However, the crossover point in terms of cost – the point at which penetration rates are high enough to warrant a switched telephone company type architecture – depends strongly on the data rate and price of the service.

The two conclusions that can be drawn from the previous studies of these architectures are that i} to reach significant penetration rates all architectures require significant investments, ii} intermodal competition between telephone and cable, if it is permitted to exist, is extremely powerful based on the differences in technology.

Wireless technologies, including fixed terrestrial, mobile wireless, and satellite, all offer alternatives to wired technologies for advanced telecommunications services. Although these technologies probably are not the most economical means of providing advanced telecommunications services to the majority of residential subscribers due to limitations of spectrum and technical limitations associated with mobility, they provide the ability to serve specialized markets which account for a significant percentage of the market for advanced services. This market segment is likely to include businesses of all sizes, rural subscribers of broadband services, and subscribers willing to pay a premium for mobility. In addition, these technologies can serve as a "cap" on the exercise of market power that may exist in particular markets. For example,

---

[9] N. Omoigui, M. Sirbu, C. Eldering, and N. Himayat, "Comparing Integrated Broadband Architectures from an Economic and Public Policy Perspective," in *The Internet and Telecommunications Policy Research*, G.W. Brock and G.L. Rosston, eds. (Lawrence Erlbaum Associates, Mahwah, NJ, 1996).

emerging fixed broadband wireless services based on LMDS licenses will be able to serve segments of the residential market, and LMDS operators will be able deploy services quickly, flexibly and at relatively low costs by erecting a small number of antennas to provide services to, for example, suburban subscribers (unlike mobile architectures which require an extensive network of antennas to provide continuous services).

Further discussion of the technologies for providing broadband services is presented in Section IV.

C. "Reasonable and timely fashion"

The Commission has requested comments on what might define a "reasonable and timely fashion."[10] As vague as such statutory terms may be, there is no doubt that the marketplace has already given a definition to this term: reasonable and timely is being defined by the growing dependence of the economy on electronic commerce and the fact that growth of electronic commerce will ultimately be slowed if broadband connections cannot be established to residences and small businesses. As will be discussed in Section III, there is evidence that the demand for data transport services is increasing at a rate which is many times that for traditional telecommunication services. No existing infrastructure is capable of meeting this demand. Given this unprecedented growth, the rapidly changing nature of the marketplace and technological environment and the potentially damaging impact that over-regulation of advanced telecommunications services could have on the economy, the definition of "reasonable and timely" must be determined by the marketplace and not the Commission or any other regulatory body. The past history of telecommunications regulation provides sound evidence that no regulatory infrastructure will be

---

[10] NOI, para. 59.

able to track the demand for advanced telecommunications services and adequately regulate these services.

III. THE DEMAND FOR ADVANCED TELECOMMUNICATIONS SERVICES

Predicting the demand for digital broadband services is a little bit like predicting the demand for sandbags in Missouri as the first raindrops begin to fall in Minnesota: About all you can be sure of is that you'll need a lot of them. In the case of bandwidth, there is no doubt that the rain has begun to fall, and that a flood of significant magnitude is coming.

The Internet and the vast array of services and applications it enables will be the primary driver of demand for digital broadband for the foreseeable future. Set up nearly three decades ago for a small community of university and government researchers, the Internet has been widely accessible for nearly a decade. Only in the last few years, however, has demand for Internet access begun to rise very sharply.

The explosive growth in bandwidth demand associated with the Internet is the product of two underlying rates of growth, in (1) the number of computers connected to the Internet, and (2) the computing power of those machines.

The computers connected to the Internet consist of two types: servers or "hosts," and users or "clients." The numbers of host and clients are both growing at exponential rates. As of January 1998, the Internet had nearly 30 million host computers, over 20 times the number five years earlier.[11] The number of Internet servers is expected to quintuple, to 100 million servers in the next

---

[11] Network Wizards, Internet Domain Name Survey, January 1998, http://www.nw.com/zone/ WWW/report.html. A host used to be a single machine on the Net. Today, a single computer may host multiple systems (with multiple domain names and Web addresses). The January 1998 data reflect a new methodology for counting domain names, and the January 1998 data therefore are not strictly comparable to previous figures.

two years.[12] The implication of these growth rates is that the amount of material available to Internet users is growing explosively, making the Internet a much more attractive product to consumers.

It is not surprising, then, that the number of Internet users is also growing very rapidly. About 2.5 million U.S. users were connected to the Internet in 1990,[13] compared with more than 56 million U.S. Internet users today.[14] According to the U.S. Department of Commerce, "fewer than 40 million people around the world were connected to the Internet during 1996. By the end of 1997, more than 100 million people were using the Internet."[15] Forecasts of future worldwide growth range from 130 million to 1 billion by the year 2000,[16] and one industry analyst estimates that private user demand for Internet services is growing 85 percent a year.[17]

The impact of this explosive growth in the number of Internet users is multiplied by the rapid growth in the abilities of computers to create, store, transmit, and receive digital traffic. Since 1993, microprocessor speeds on the average $3,000 personal computer have increased by a factor of ten – from 33 MHz Intel 486s to 300 MHz (or greater) Pentium IIs;[18] modem speeds have increased

---

[12] A. Rutkowski, General Magic, Internet Trends, Feb. 1997, http://www.generalmagic.com/Internet/Trends/slide-4.html.

[13] Breakthroughs, *U.S. News and World Report*, Dec. 25 1996/Jan. 1 1996, at 101-104, 106-108.

[14] Intelliquest Press Release, Latest Intelliquest Survey Reports 56 Million American Adults Access the Internet/Online Services, Nov. 18, 1997, http://www.intelliquest.com/about/release37.htm.

[15] Lynn Margherio, *et al, The Emerging Digital Economy* (Washington, DC: U.S. Department of Commerce, 1998), p. 2. Hereafter *Emerging Digital Economy.* See also Bob Woods, "Net Users Break 100 Million Barrier – Study," *Newsbytes*, June 30, 1998, reporting on a study by Matrix Information and Directory Services. The study projects 707 million Internet consumer users by January 2001.

[16] *See* P. Rolfes, Novell CEO: Networks Put a Face on Internet, *Columbus Dispatch*, Nov. 20, 1997, at 1F (130 million by 2000); J. Welsh, AFather@ of Internet Expects Bright Future for Technology, *Wisconsin State Journal*, Nov. 18, 1997, at 1C (300 million by 2000, according to Vint Cerf); B. Metcalfe, CamCon 97 Draws Out the Digerati to Ponder the Future of the Internet, *InfoWorld*, Nov. 17, 1997, at 187 (1 billion by 2000, according to Nicholas Negroponte).

[17] D. Molony, The Big Squeeze, *Communications Week International*, February 3, 1997 (citing Carl Howe, senior analyst at Forrester Research Inc, Cambridge, Massachusetts).

[18] *Compare* M. Miller, Looking Back – 1990-94: The Windows Era, *PC Magazine*, Mar. 1997,

by a factor of twenty – from 2,400 bits per second to 56,000;[19] and data storage capabilities have increased by a factor of thirty – from 240 megabyte hard disk drives to 8 gigabytes.[20] By all indications, the power of digital machines will continue to increase at comparable rates indefinitely into the future. These advances enable information and data of all kinds to be processed more efficiently, in much greater quantities and at much faster speeds. The rise in processing power makes possible a wide variety of new electronic information services and computer-based communications applications.

The result of these two phenomenon is that the overall demand for digital bandwidth is growing at a staggering rate. According to one analyst, the total amount of digital traffic will grow from 32 quadrillion bits per day in 1996 to over 400 quadrillion bits per day in 2006, an average annual growth rate of nearly 70 percent.[21] Bellcore predicts that demand for bandwidth will increase at least 20-fold in the next five to ten years.[22] John Sidgmore, the Chairman of WorldCom, recently stated that demand for bandwidth on his company's backbone increased 1,000 percent in 1997 and that it is doubling every 100 days.[23]

---

http://www.zdnet.com/pcmag/special/anniversary/back/lkr5.htm with Sneak Peek: Dell Dimension XPS D266 vs. Gateway G6-300XL, Oct. 1997, http://www.zdnet.com/pccomp/sneakpeeks/snkpk1097/gate.html.

[19] *See* A. Goldstein and J. Files, Chip Industry Needs Helping Hand, Dallas Morning News, June 16, 1997, at 2D.

[20] *Compare* R. Manning, All Systems Go, *Sacramento Bee*, Feb. 6, 1996, at D1 *with* Sneak Peek: Dell Dimension XPS D266 vs. Gateway G6-300XL, Oct. 1997, http://www.zdnet.com/pccomp/sneakpeeks/snkpk1097/gate.html.

[21] More Traffic on The I'way, Industries in Transition (Jan. 1997).

[22] *See* M. Janah and M. Thyfault, Networks: Telecommuters Find Data-moving a Snap, *InformationWeek*, Apr. 7, 1997.

[23] L. Bowman, WorldCom Sounds the Bandwidth Alarm, PC Week Online, Jan. 29, 1998, http://www.zdnet.com/pcweek/news/0126/29aworld.html; M. MacLachlan, WorldCom Makes Megadeals to Develop Network Infrastructure, *Internet Week*, Oct. 6, 1997. See also *Emerging Digital Economy,* p. 2.

Indeed, data traffic generated by computers and other electronic devices will soon exceed all other types of traffic on communications networks. Internet pioneer Vint Cerf recently predicted that by the year 2010, 90 percent of all communication could be data, and only 10 percent voice.[24] Other studies have predicted that by 2001, voice will make up only 4 percent of total traffic on public and private telecommunications networks, whereas data will make up 95 percent and video and fax the remaining 1 percent.[25]

A. Broadband Demand in Residential Markets

Most households already have access to large amounts of bandwidth, but most of it is analog and one-way. Virtually all households (97 percent) have telephone wires that supply more than enough bandwidth for voice communications. Most households (65 percent) also have cable wires that, on average, supply 50 channels of video programming.[26] Almost all households that don't receive cable do receive over-the-air television, which delivers at least 12 channels of video – and will presently, through digital television technology, deliver much more.

Demand for analog bandwidth has increased only modestly in the last decade. While the number of lines in use has grown steadily, and faster than the rate of population growth, usage of voice lines has held roughly constant at 25 minutes per day per line over the past 15 years or more.[27]

---

[24] S. Murray, Quieter Future Forecast, *Baltimore Sun*, Jan. 23, 1998, at 1C.

[25] More Traffic on The I'way, Industries in Transition (Jan. 1997).

[26] See Duesterberg and Pitsch, *The Role of Competition and Regulation in Today's Cable TV Market* (Washington, DC: The Hudson Institute, 1998), p. 25. Nearly 60 percent of cable subscribers have access to 54 channels of programming, or more.

[27] *See* FCC Trends in Telephone Service 33 (Mar. 1997) (The level of local calling has remained relatively constant over a long period of time despite the introduction of facsimile machines, computer modems and other devices that use telephone lines. Increases in long distance calling have caused the total usage per line to increase from 46 minutes in 1980 to 52 minutes in 1995.•). The "minutes" counted by the FCC actually double-count the total usage of the line.

Television viewing has likewise held constant at about 7 hours per day over the past decade, slightly higher for households with cable.

Residential demand for digital bandwidth, by contrast, is exploding. At least one-quarter of U.S. households now have a personal computer (PC) equipped with a modem that can be used to access data-based information services.[28] Demand for modem-equipped PCs is continuing to expand at a rapid rate.[29] The new generation of sub-$1,000 entry-level PCs have attracted many first-time buyers;[30] prices for entry level computers had dropped to as low as $500 by the middle of 1998.[31] Indeed, in May 1998, Gateway2000 introduced its "Your:)Ware" program, which allows consumers to purchase a fully-equipped PentiumII computer, along with access to the Internet, for a monthly fee of $49.95 per month.[32]

Computer software has also spurred residential demand for computer-based services. User-friendly software programs such as Netscape Navigator and Microsoft Internet Explorer have contributed greatly to the success of the World Wide Web. According to one study, the demand for

---

[28] According to Jupiter Communications, at the end of 1996 nearly 40 million households in the U.S. have PCs, for a penetration rate of 39 percent. Over 70 percent – 27 million – of these households have modems connected to their PCs, and over half of them – 15 million – use the Internet or other online services. Jupiter Communications Press Release, New Devices and Technologies Will Drive Net Into 36 Million Homes by 2000, Jan. 6, 1997.

[29] U.S. sales of modems increased from 3.3 million units in 1990 to 19 million in 1995. Forecast Shipments of Modems, Computer Industry Forecasts, Jan. 15, 1997, citing High-Performance Modems, Information Week, Oct. 21, 1996, at 26. The MMTA attributes virtually all of this growth to the rise in Internet use. MultiMedia Telecommunications Association, 1996 MultiMedia Telecommunications Market Review and Forecast 13 (1996). The Data Analysis Group forecasts sales of 47 million modems in three years.

[30] As IDC Research observed, *declining PC prices and the introduction of the sub-$1,000 PC have helped to drive consumer adoption of the PC and therefore, online services in the home.* IDC Research Press Release, Web Has Reached Mass Market Proportions (1997) (quoting IDC senior analyst Jill Frankle).

[31] J. Carlton, PCs Under $1,000 Attract New Kinds of Customers, Wall St. J., Jan. 26, 1998, at B8.

[32] *See*: http://www.gateway2000.com/frameset2.asp?s=home&url=home/aboutgw/pressreleas/pr052798/

some six million residential second telephone lines in 1995 – almost half of all second residential lines – can be attributed principally to on-line access.[33]

Most major consumer on-line service providers have embraced open standards and now provide access to the Internet, in addition to specialized services such as bulletin boards, chat rooms, live conferencing, software, home shopping and database services specializing in business, legal, medical and other technical information. On-line services still continue to attract increasing number of subscribers willing to pay for specialized services. It is estimated that the number of subscribers to consumer on-line services will continue to increase at a rate of 70 to 100 percent a year through 2000.[34] America Online's subscriber base has increased from 303,000 in 1993 to over 11 million today.[35]

The available evidence suggests that demand for bandwidth in the residential market is highly elastic. A recent study by Robert Crandall and Chuck Jackson, for example, estimated that only four million consumers would be willing to pay $70 per month for an upgrade from 56.6 kb/s access to 1.1 Mb/s, but 20 million would pay $25.[36] As Crandall and Jackson are careful to note, such estimates are based on a relative paucity of data. However, they are consistent with other data, such as a recent study by the Yankee Group. That study reported that nearly two-thirds of online

---

[33] Lee L. Selwyn and Joseph W. Laszlo, Economics and Technology, Inc, The Effect of Internet Use on the Nation's Telephone Network (Jan. 22, 1997) (prepared for the Internet Access Coalition). According to Bell Atlantic, between one-third and two-thirds of second lines are purchased solely for data services, such as Internet access and fax machines. Joint Comments of Bell Atlantic and NYNEX on Notice of Inquiry at 11, Usage of the Public Switched Network by Information Service and Internet Access Providers CC Dkt No. 96-263. (F.C.C. Mar. 24, 1997).

[34] U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 26-8 (1997).

[35] 1996 and 1997 America Online Annual Reports; J. Kornblum, AOL Reaches 11 Million Market, CNet News.com, Jan. 20, 1998, http://www.news.com/News/Item/0,4,18294,00.html.

[36] *See* Robert W. Crandall and Charles L. Jackson, *Eliminating Barriers to DSL Service,* unpublished manuscript, May 1998.

households are interested in high-speed Internet access, but only 27 percent might be willing to pay $40 per month (about the same as the average cable bill) for unlimited high-speed access.

B. Broadband Demand in Business Markets

Businesses have been using digital bandwidth much longer than residences. Electronic Data Interchange, a protocol for computer-to-computer transaction of billing, purchasing, invoicing, and other business functions, pre-dates the Internet.[37] Businesses have also been big users of electronic funds transfers and electronic mail. In recent years, business usage of Internet services has of course grown very rapidly as well.

Until the rise of the Internet, many businesses were served by expensive private or leased facilities, obtained from value-added network (VAN) providers such as GE Information Services (GEIS) and IBM, as well as from local telephone companies, competitive access providers and long-distance carriers.

As in the residential market, business demand for digital bandwidth is being propelled by the personal computer. Nearly 70 percent of all computers are owned by businesses.[38] Eighty percent of those machines are networked,[39] and 44 percent are connected to the Internet.[40] According to Forrester Research, by the year 2000, 363,000 businesses – a full 100 percent of the nation's large businesses, 50 percent of mid-sized businesses and 30 percent of small businesses – will be

---

[37] More than 100,000 U.S. companies use EDI daily to send electronic purchase orders, invoices, and other standardized documents to suppliers and customers.

[38] 38 percent of all computers are owned by large businesses, and 31 percent by small and medium businesses.

[39] According to IDC, over half of the business PCs in the United States are now connected via a LAN and 80 percent of all organizations with more than 100 employees have a LAN installed. U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 27-14 (1997).

[40] New York and the Future of Office Technology, *Westchester County Business Journal*, May 5, 1997, at 16 (citing IKON study).

connected to the Internet.[41] It is estimated that over 90 percent of Fortune 1000 companies have either established or plan to establish a corporate Intranet.[42] From 1995 to 1996 the percentage of Fortune 500 companies with Web sites grew from 34 to 80 percent.[43] Leased T1 lines are increasingly used to access the Internet and public switched networks. According to analyst Dataquest, the number of installed T1 lines will surge by about 23 percent per year during the next two years.[44]

While much of the bandwidth required by businesses in the past has been used for intra-corporate communications, future demand will largely be shaped by how much business and commerce is actually conducted over the Internet. Electronic commerce involves the sale and purchase of goods electronically and "any kind of communication or collaboration with customers, suppliers, and other business partners via computers linked to a network."[45] A great deal of the commerce conducted on private or leased facilities can readily be shifted to the Internet. Many companies are creating methods to make electronic commerce easier and more secure.

A great deal of business-to-business commerce is transacted today via fax, phone, or through private electronic links. At present, businesses do about ten times as much on-line business with

---

[41] *See* U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 28-24 (1997).

[42] U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 27-14 (1997).

[43] C. Anderson, In Search of a Perfect Market, Survey – Electronic Commerce, *The Economist*, May 10, 1997, http://www.economist.com/editorial/freeforall/14-9-97/index_survey.html (hereinafter *Economist Survey*).

[44] S. Salamone, It's Not Your Mother's T1 Anymore, TechWire, Apr. 23, 1997. That translates into an additional 300,000 T1 lines this year and another 380,000 next year, bringing the total number of installed lines to 1.98 million by the end of 1998. *Id.* Companies that want to establish a presence on the Internet need more connectivity, said industry analyst David Strom of David Strom Inc. in Port Washington, N. Y. The proliferation of Internet service providers has made T1 a cost- effective choice. The monthly charge for a T1 is a function of distance. The more ISPs, the more POPs, Strom said, noting that most corporations will find they have an ISP POP in their vicinity. *Id.*

[45] U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 28-22 (1997).

other businesses as they do with consumers.[46] Essentially all business-to-business traffic can migrate to digital networks, and it is rapidly doing so. A recent survey by *The Economist* estimated that the value of business-to-business electronic commerce conducted over the Internet would increase to between $50 and $150 billion by 2000.[47] Forrester Research has found that business-to-business commercial transactions over the Internet will hit $8 billion this year, and projects a $327 billion dollar annual market in 2002.

Video conferencing is another application that may generate significant new demand for digital bandwidth in business markets. According to a 1997 study, 76 percent of businesses are either currently using video conferencing technology, undergoing trials, or otherwise planning for its future use.[48] The video conferencing industry has experienced an annual growth rate of 100 percent in the last year. Video conferencing technology is rapidly becoming easier to set-up and cheaper to purchase.

On-line retail commerce presents by far the most important prospect for the longer term, affecting both business and residential demand. Estimates of the volume of electronic commerce (measured in terms of the value of the underlying transactions) on the Internet by the year 2000 range from $10 billion to $230 billion.[49] These, in turn, would generate between $3 billion and $30 billion in revenues for electronic commerce service facilitators. According to a survey by

---

[46] Economist Survey, *supra*.

[47] Economist Survey, *supra* (citing Forester, Yankee Group, IDC and Cowies/SIMBA).

[48] J. Linehan, A Bit Too Cautious, Perhaps?, *Communications Week*, July 21, 1997, at 36.

[49] Economist Survey, *supra* (citing Forrester, Yankee Group, IDC, Cowies/SIMBA, Jupiter, Multimedia Research Group). Another research firm, Mountain View, California-based INPUT, predicted in a February 1996 report that worldwide sales of goods and services traded over the Internet would grow from $70 million in 1995 to $255 billion in 2000, a compounded growth rate of more than 400 percent a year.@ U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 28-24 (1997).

CommerceNet, an industry consortium, and Nielson, a media-research firm, 73 percent of Internet users are using the Web for commerce, and 10 million Web users in the U.S. and Canada have actually made on-line purchases.[50] According to projections by International Data, a Massachusetts consultancy, by 2000 46 million consumers in America alone will be buying online.

C. Supply and Demand

Estimating demand for digital bandwidth is particularly difficult because of the mutually reinforcing impacts of growth in the constituent parts.[51] Because networks become more valuable to each as the overall number of users (and quality of service) expands, innovation and growth in individual market segments leads to faster growth in others.[52] Computers boost demand for Internet services; Internet services boost demand for computers. U.S. computer sales reached $16.7 billion in 1994; they are forecast to reach $73 billion in 2002.[53] The number of publicly-traded U.S. computer companies has risen from a little over 400 at the beginning of 1994 to over 1,000 today. These companies have a total market value of nearly $1.4 trillion, a 400 percent increase from 1994. In 1996 and 1997, 391 Internet and computer industry companies held initial public offerings, generating $19.5 billion[54] in market capitalizations. The high-tech sector is now the largest industry

---

[50] *Emerging Digital Economy,* p. 35.

[51] The various factors driving the demand for digital bandwidth have had a profound impact on the U.S. economy. The Department of Commerce reports that the Information Technology sector of the economy has accounted for 25 percent of U.S. GDP growth in recent years and that "IT and electronic commerce can be expected to drive economic growth for many years to come." *Emerging Digital Economy*, p.2.

[52] See Kevin Werbach, "Digital Tornado: The Internet and Telecommunications Policy," Federal Communications Commission, PFF Working Paper Series #29, March 1997, p. 3. ("[I]t is valuable to understand the Internet as a feedback loop. A feedback loop occurs when the output of a system is directed back into the system as an input. Because the system constantly produces fuel for its own further expansion, a feedback loop can generate explosive growth.")

[53] U.S. Department of Commerce, *U.S. Industry & Trade Outlook >98*, at 26-4 (1997).

[54] S. Galante, 1997 IPOs Sputter, Then Pick Up, CNet News.com, Dec. 22, 1997, http://www.news.com/News/Item/0,4,17554,00.html.

in the U.S., with sales of $866 billion, 57 percent higher than in 1990.[55] High-tech employment is also booming, employing 4.3 million people in 1996, with over a quarter of a million added between 1995 and 1996.[56] Growth in each one of these sectors helps propel growth and demand in all the others.

Increases in the actual supply of bandwidth also propel broadband demand.[57] Competitive access providers have deployed high-capacity fiber optic networks in most major cities. CAP revenues from private line and data services have risen from $216 million in 1993 to $695 million in 1996.[58] The number of CAPs nearly doubled, from 41 to 78, in that same period.[59] Four companies – IXC Communications, Qwest Communications, William Communications Group, and Level 3 Communications – are currently spending $5.9 billion to build long-haul fiber networks extending 63,000 miles, to be completed by the end of 1999.[60] Several companies and consortia are also investing billions to deploy large constellations of satellites to provide broadband access. Teledesic and Celestri will invest $9 billion and $13 billion, respectively, to develop world-wide

---

[55] S. Lohr, Information Technology Field Is Rated Largest U.S. Industry, *N.Y. Times on the Web*, Nov. 18, 1997, http://www.nytimes.com/library/cyber/week/111897study.html (citing American Electronics Association study).

[56] S. Lohr, Information Technology Field Is Rated Largest U.S. Industry, *N.Y. Times on the Web*, Nov. 18, 1997, http://www.nytimes.com/library/cyber/week/111897study.html (citing American Electronics Association study).

[57] The FCC's Kevin Werbach noted that the Internet, however, is driven by a particularly powerful set of self-reinforcing conditions. Some supply factors (such as the availability of higher-capacity networks) permit an expansion of demand (for example, by allowing bandwidth-intensive services such as high-resolution video transmission). Like a digital tornado, the vortex continues, as the new level of demand creates the need for additional capacity, and so forth. *See* K. Werbach, FCC Office of Plans and Policy, OPP Working Paper No. 29, Digital Tornado: The Internet and Telecommunications Policy 4, 5 (Mar. 1997).

[58] Connecticut Research, 1994 Local Telecommunications Competition at II-15 (6th ed. 1994); New Paradigm Resources Group & Connecticut Research, 1997 Annual Report on Local Telecommunications Competition 28 (8th ed. 1997).

[59] Connecticut Research, 1994 Local Telecommunications Competition at II-1 (6th ed. 1994); New Paradigm Resources Group & Connecticut Research, 1997 Annual Report on Local Telecommunications Competition 7 (8th ed. 1997).

[60] J. Keller, Ex-MFS Managers Plan to Build Global Network Based on Internet, *Wall St. J*, Jan. 20, 1998; S. Schiesel, From a Supplier of Gas Comes a Digital Pipeline, N.Y. Times, Jan. 12, 1998, at D10.